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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT APOLLO

QUARTERLY STATUS REPORT

NO. 2

FOR PERIOD ENDING
DECEMBER 31, 1962

MANNED SPACECRAFT CENTER



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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO SPACECRAFT PROJECT

STATUS REPORT NO. 2

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FOR

PERIOD ENDING DECEMBER 31, 1962

By Manned Spacecraft Center

FOREWORD

This report is the second in a series of reports on the status of the APOLLO Spacecraft Project for the Manned Lunar Landing Program. The first status report described the functions and requirements of the spacecraft modules and systems as well as their development status through September 30, 1962. This second report reflects activities and changes in status during the last quarter of 1962.

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SUMMARY

The spacecraft and launch vehicle, being developed by the Manned Spacecraft Center (MSC) and George C. Marshall Space Flight Center (MSFC), respectively, comprise the APOLLO Space Vehicle (fig. 1). The configuration of the APOLLO spacecraft is shown in figure 2.

The spacecraft is composed of separable modules including a Command Module which houses the crew from the earth to the vicinity of the moon and the return to the earth; a Service Module which contains propulsion and other systems; and a Lunar Excursion Module which separates from the Command and Service Modules when in lunar orbit and descends to the lunar surface for manned exploration.

The Saturn C-5 will be the basic launch vehicle for lunar missions. The C-5 consists of three stages, the S-IC, S-II, and S-IVB. The S-IC uses LOX-RP-1 propellants and five F-1 engines. The S-II stage uses LOX-LH₂ propellants and five J-2 engines. The S-IVB stages uses LOX-LH₂ propellants and one J-2 engine.

Major accomplishments of Project APOLLO during this reporting period have been:

a. Grumman Aircraft Engineering Corporation was selected for negotiation of a contract to develop the Lunar Excursion Module. Negotiations were completed on all major aspects of the contract. Formal signing of the contract is expected in early January 1963.

b. Prenegotiations began with the North American Aviation, Inc.-Space and Information Systems Division to formalize their contract to develop the APOLLO Spacecraft Command and Service Modules. Formal negotiations will begin in early January 1963.

c. Negotiations were begun with the Massachusetts Institute of Technology to formalize their Industrial Support contracts with A. C. Spark Plug Division of General Motors Corporation, and Kollsman Instrument Corporation. Their contract with Raytheon Company was formalized during this period.

d. The General Dynamics/Convair contract to develop the Little Joe II launch vehicle was formalized.

e. The space suit contract was formalized with Hamilton-Standard.

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f. Approximately 95 percent of the Command Module structural design drawings and 65 percent of the Service Module structural design drawings have been completed.

g. Three boilerplate spacecraft have been completed and shipped to vendors for parachute drop and water impact tests. Manufacture of Boilerplate 6, which will be used for pad abort tests is progressing.

h. Fabrication of detail parts for the first Command Module airframe is underway. This airframe will be used for propulsion development testing.

i. The soft mock-ups of the APOLLO Command and Service Modules have been completed.

Principal design changes to the APOLLO Command and Service Modules have been completed. Principal design changes to the APOLLO spacecraft during this period are as follows:

a. The Launch Escape System (LES) tower structure was redesigned to reduce rocket exhaust impingement effects. The release mechanism used on the LES tower, forward heat shield, and Command Module-Service Module interface was changed from an electro-mechanical to an electro-explosive system. The initiating squibs for the electro-explosive system were also standardized.

b. The catalytic burner was deleted from the Environmental Control System.

c. The guidance and navigation computer is being redesigned to incorporate micrologic units throughout the computer. This should decrease the volume and weight as well as result in increased reliability.

d. The space sextant was redesigned to eliminate the untraprecision gear drives and to allow the landmark line-of-sight mechanism to be bore-sighted with the shaft drive axis.

e. The Stabilization and Control System horizon scanner and sun seeker were deleted.

f. The Service Module Reaction Control System nozzles were canted $9\frac{1}{2}^{\circ}$ to eliminate exhaust plume heating of structure.

g. The automatic propellant utilization system for the Service Module Propulsion System has been replaced by a manual control system.

h. Separate batteries in the Electrical Power System will be used for pyrotechnic ignition. The automatic control system for paralleling a battery with the power line when low voltage is detected has been deleted. A central inverter system will be used. Three-phase a-c type motors rather than brushless d-c motors will be used.

i. The Deep Space Instrument Facility transponder will be relocated to the Command Module.

MISSION PLAN

The mission objective of Project APOLLO is the landing of men on the lunar surface, limited observation and exploration of the lunar surface by the crew in the landing area, and return of the crew to the earth.

A Project APOLLO Lunar Landing Mission Design Plan (ref. 1) has been prepared. This plan presents ground rules, trajectory analysis, sequence-of-events, crew activities and contingency operations for early Project APOLLO lunar landing missions. Changes which might occur in planning subsequent missions are also briefly presented in the design plan.

Several studies have been initiated to develop better definition of the mission plan.

a. Major emphasis in the trajectory analysis area has been on developing a generalized trajectory simulation. These generalized trajectory simulations will enable the computation of accurate trajectories from earth launch through lunar operations and back to earth landing when given the launch time and date, parking orbit altitudes, parking orbit duration, transfer times, landing sites and other trajectory restrictions are required for the computer to determine the solution. In addition, these simulations will be capable of computing abort trajectories from any point in the mission to preselected landing sites. Feasibility and parametric studies, using approximate methods and/or precise computation over limited portions of the mission, are complete to the point where optimization of the many variables and greater accuracy in trajectory parameters is required before further studies can be made.

b. In the sequence-of-events and crew activities areas, "time-lines" have been developed showing the sequential arrangement of major activities. Also, analysis of the interface between the crew and each spacecraft system has been undertaken to determine which system control elements should be manual and which should be automatic.

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c. Progress in the development of contingency operations has been shown in (1) component-failure effects analysis and (2) procedures to be followed for an abort at any point in the mission. An analysis of the launch vehicle and spacecraft component failures is underway to determine where redundant components are required and also to develop a procedure to be followed to escape impending disaster and/or acquire a method or component to minimize the failure's effect on the mission. Also, a study to develop a crew safety procedure to be used following an abort during any phase of the lunar landing mission has been initiated. This study will determine trajectory alternatives available, including return times, propulsion requirements, landing sites, with the objective of maintaining maximum reliability.

SPACECRAFT AND ADAPTER DESIGN AND DEVELOPMENT

The APOLLO Spacecraft is composed of a Command Module, Service Module, and Lunar Excursion Module. An adapter provides the attachment between the launch vehicle and the spacecraft. The Lunar Excursion Module is housed in this adapter during launch.

North American Aviation, Inc., Space and Information Systems Division, is the prime contractor for development of the Command and Service Modules, adapter, associated Aerospace Ground Equipment (AGE), and spacecraft integration. The two major associate contractors are Massachusetts Institute of Technology Instrumentation Laboratory for development of the Guidance and Navigation System and Grumman Aircraft Engineering Corporation for development of the Lunar Excursion Module.

COMMAND AND SERVICE MODULES

The Command Module is the Space Vehicle command center from which all crew-initiated control functions are performed during launch, translunar, transearth, earth reentry and landing phases of the mission.

The Service Module is unmanned and contains the propulsion systems for midcourse correction, entry into and exit from lunar orbit, and for lunar orbit rendezvous as a backup to the Lunar Excursion Module propulsion. The Service Module is non-recoverable and will be jettisoned prior to earth reentry.

In October 1962, the MSC and North American Aviation, Inc., began preparations toward formalizing the APOLLO Spacecraft Development Contract, NAS 9-150. The MSC reviewed the North American Aviation,

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Inc., contract package, negotiated a program plan position with the Prime Contractor, and has also reviewed the Prime Contractor cost proposal. Review of North American Aviation's subcontractors cost proposals will be completed during the first week of January. Formal contract negotiations with North American Aviation will begin on January 7, 1963, and will be completed in early March 1963.

Launch Escape System

Two design changes to the Launch Escape System have occurred during this reporting period. They are:

a. Launch escape tower truss members were relocated in the upper bay to remove them from the exhaust path of the escape motor. The topmost cross-members and diagonals were replaced with diagonal members framing into a central ring.

b. The cable-actuated toggle release system for the escape tower was replaced with explosive bolts on the tower base.

Two successful static firings of the escape motor were conducted on schedule. A static firing of four pitch-control motors was completed in late December 1962. The first static firing of the tower jettison motor, was also successfully accomplished in mid-December, 1962. Launch escape and tower jettison motor igniter tests have verified predicted performance calculations. High altitude tests at the Arnold Engineering Development Center of the tower jettison motor are now scheduled for early February 1963. Fabrication of the first titanium launch escape tower is progressing satisfactorily. The tower will be used on Boilerplate 19.

Command Module Structural System

There have been no major changes to the Command Module structural system. The release of structural design drawings for the Command Module is 95 percent complete with 100 percent release scheduled for January 1963.

A study of a back-up heat shield design was completed by AVCO and as a result of this study, an alternate to the original "tile" type heat shield design has been proposed. The new design features an ablator-filled open face fiber glass honeycomb applied on a stainless steel honeycomb sandwich substructure. The heat shield design is identical to Project GEMINI except that the ablator material is AVCOAT 5026 Low Density (which is not generally considered an elastomeric compound) and the backup structure is steel instead of fiber glass. The manufacturing techniques is basically the same as that for the Project GEMINI-type heat shield. Basic thermal performance and mechanical tests

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of the new shield design have been performed by AVCO. The results indicate excellent thermal performance and have uncovered no mechanical inadequacy.

After MSC concurrence, North American Aviation, Inc., accepted AVCO's latest design and also directed discontinuance of any further effort on the original tile design. Although the new AVCO design is by far the better of AVCO's two candidates, the MSC has withheld approval of manufacturing facility funds from AVCO since there are still questions about the mechanical integrity of AVCO's design and about the requirement that the substructure be shipped to AVCO for application of the heat shield materials.

Other considerations being equal, a backup structure having the mechanical and fabrication features of the GEMINI heat shield is preferable, however, present data leaves doubt that the thermal performance efficiency of the elastomeric ablators are competitive with the AVCOAT 5026 LD. Accordingly, North American Aviation, Inc., and the MSC are conducting a study and experimental program on an alternate heat shield. It is hoped that this study will provide sufficient data by about February 1, 1963, to allow a first-order assessment of the feasibility of an elastomeric ablator heat shield. Experimental tests in the Plasmadyne facility to determine ablator thermal performance will envelop the major portion of this study. Mechanical and other tests are being conducted, but on a non-interference basis with the tests at Plasmadyne. AVCOAT 5026 LD specimens are being tested as control points. General Electric/ESM-1000, Emerson/T-500, and Dow Corning/DC-235 ablator materials were selected as representative materials.

North American Aviation, Inc., has been authorized to proceed with the detail design and fabrication of the brazed steel honeycomb substructure independent of the outcome of the alternate heat shield study. However, North American Aviation, Inc., will insure that the detail design and manufacturing technique selected by them for the brazed steel substructure will not preclude the subsequent use of any of the selected elastomeric material or the AVCOAT 5026 LD.

Service Module Structural System

The Service Module structural design is 65 percent released, with 100 percent release scheduled for May, 1963. The present Service Module length is 155 inches.

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Crew Equipment

The general arrangement of the APOLLO Spacecraft instrument panel has been established to maximize the provisions for manual control and observation of the flight's progress by the crew. The controls and displays in the three stations are listed below:

a. Control Station (left side of main panel)

Flight director attitude indicator (8-ball)

Energy management controls and displays

Computer controls

Stabilization system controls

Backup reentry display

Clocks

Other mode selection controls

Sequencing (left side console)

b. Center Station (center of main panel)

Service Module Propulsion Systems management (accessible from control station)

Reaction Control Systems management (accessible from control station)

Environmental Control Systems management (accessible from systems management station)

Audio

Sequencing

c. Systems Management Station (right side of main panel)

Power distribution

Fuel cells

Cryogenics

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Telecommunications

Antenna control

Radiation (right side console)

The use of only one flight director attitude indicator (8-ball) effects a substantial weight and power **savings**.

Selection of specific switches and dial faces and the preparation of specifications for all detailed control-display parameters is still under study by North American Aviation, Inc. Detailed design requirements for launch vehicle monitoring and control will be established by the MSC in January 1963.

An extensive review of navigation controls and displays was held at Massachusetts Institute of Technology in early December. The MSC and Massachusetts Institute of Technology are studying methods whereby the astronaut can use the telescope and sextant while in a pressurized suit. Since eyepiece weight increases very fast with small increases in eye relief requirements, the MSC is studying helmet designs which will permit the astronaut to place his face directly against the helmet visor while making navigation sightings. Additional discussion of the space suits is included in the Space Suit System section of this report.

The first working mock-up of the crew couch was viewed during the December mock-up inspection. The couch and shock attenuation system has been compared to a "complex landing gear". The couch and shock attenuation system design must meet all the following requirements:

- a. Headward, tailward, sideward, and backward shock attenuation.
- b. Headward, tailward, and sideward couch positioning for various mission phases.
- c. Body angle adjustments
- d. Astronaut size adjustments
- e. Incorporation of hand and foot attitude controllers
- f. Removal of center couch
- g. Use of center couch as a bed

Both the MSC and North American Aviation, Inc., are investigating the possible use of a net couch with reduced rebound characteristics.

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A net couch would result in a substantial weight savings in the couch and supporting structure. The principal problem of the net couch is rebound upon impact.

The MSC has recently completed a program of human shock acceleration tolerance testing. The work was performed by several government agencies and has led to an extension of the known physiological tolerance limits. A follow-on program to gather additional data is currently under way.

North American Aviation, Inc., has evaluated various subcontractor food proposals. It is expected that a contract will be negotiated in January 1963, with Whirlpool-Seegar, Inc., (Project GEMINI food system supplier) or Stanford Research Institute to supply the food for Project APOLLO missions. In either case, the food is principally of the freeze-dried type which will be used in Project GEMINI. Certain commercial applications such as soups purchased for home use and various other foods prepared by restaurants will fill out the food complement.

For physiological monitoring of the crew during Lunar missions, emphasis will be placed on the in-flight use of clinical methods (i.e., oral thermometer, blood pressure cuff, manual pulse timing, et cetera) rather than telemetry of bioinstrument data. However, the requirements for bioinstrumentation telemetry were not completely deleted. For operational missions one channel will be available for intermittent use. The crew will have several sets of sensors such as ECG, respiration, and others to be determined later. Any one set of the sensors can be donned at any time, plugged into the spacecraft telemetry transmission system and transmitted on the single telemetry channel. However, additional bioinstrumentation telemetry may be used during early orbital missions.

During extravehicular operations, prime reliance will be placed on voice communications, but the space suit communications system will be capable of telemetering one high-frequency physiological function (respiration or ECG) and six suit temperatures, pressures or quantities (low-frequency data).

North American Aviation, Inc., has made several calculations of radiation dose. Dosage is within emergency limits for all solar flare models except the one specified in the Project APOLLO work statement; the work statement model is considered to be too conservative. The MSC is currently developing a model to simulate "worst" solar flare conditions for use in dose calculations; this model will simulate conditions "worse" than any observed event; it will correspond to a one percent probability during solar maximum (based on International

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Geophysical Year observations) and it is expected that the model will dictate dosage in the tolerance limit range based on little or no shielding except that inherent in vehicle structure and systems.

North American Aviation, Inc., is developing a master radiation shielding computer program which will permit accurate dose calculations at any point within the spacecraft. The MSC (with assistance from Oak Ridge National Laboratory) reviewed the status of the computer program in November. To speed the availability and utility of the computer program, North American Aviation, Inc., will:

- a. Make simplifying assumptions with regard to secondaries; such simplifications are justified on the basis of NASA funded Atomic Energy Commission shielding tests with proton accelerators.
- b. Simplify human body geometry.
- c. Provide means for calculating change in dose due to localized vehicle design changes without performing calculations for the entire vehicle.

Environmental Control System

The MSC has completed the atmospheric validation program for the pure oxygen atmosphere at 5 psia. Republic Aviation Corporation, USAF School of Aviation Medicine, and USN Air Crew Equipment Laboratory have tested nearly 20 subjects for 14 days each on APOLLO spacecraft atmosphere. These tests indicate that this atmosphere is physiologically acceptable.

The MSC hopes to change the wick-type water separator to a centrifugal water separator if costs and program delays are not excessive. An appropriate change in the overall water management separator scheme would permit use of the centrifugal separator without a booster pump whereas a pump may still be required with the wick separator. The centrifugal water separator design concept is generally more fully qualified than the wick separator.

The all high-pressure (20 psia) water management system design is to be changed to a dual-pressure water design. High pressure collection (20 psia) of fuel cell water is necessary to prevent flashing. The dual pressure scheme has the waste water tank at 5 psia; this permits direct discharge from the centrifugal separator without a pump.

The gas analyzer has been temporarily removed from the APOLLO spacecraft design. Only a single CO₂ sensor is now planned. The MSC is carrying out a program to define gas analyzer requirements and

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qualify the design of a flight item. The program will be completed in March 1963, and at that time a decision will be made regarding use of a gas analyzer on Project APOLLO flights. If the gas analyzer is not used as operational hardware, it may be put aboard early orbital flights as a part of the Research and Development Instrumentation. The necessary volume and power allotment is being reserved for the gas analyzer if its use is determined necessary and feasible.

The catalytic burner has been deleted. Most undesirable gases will be removed by the charcoal filter. The only remaining undesirable gases are light compounds with the most important of these being carbon monoxide and methane. However, their concentrations are far below human tolerance levels.

Guidance and Navigation System

The MSC conducted contract negotiations with Massachusetts Institute of Technology's Industrial Support Contractors, A. C. Spark Plug Division of General Motors Corp., Raytheon Company, and Kollsman Instrument Corp. Contract negotiations with Raytheon Company for the guidance computer commenced on October 8, 1962, and were completed. The contract, including the technical Statement of Work, has been prepared for review, approval and execution. Contract negotiations with A. C. Spark Plug Division of General Motors Corp., are currently being held. The Statement of Work for the Kollsman Instrument Corp., contract was revised and is now being published.

The Guidance and Navigation System space sextant has been redesigned to eliminate ultraprecision gear drives and to allow the landmark line-of-sight mechanism to bore-sight with the shaft drive axis. The simplified design will improve reliability and also be easier to fabricate. The layout of the new sextant design is substantially complete. The scanning telescope design has been completed and the preparation of detail drawings has begun. Preliminary drawings for the optical elements and principal details of the scanning telescope head are 75 percent complete.

The computer which has 12,288 words of fixed memory and 1,008 words of erasable memory is currently undergoing a design change to incorporate micrologic units throughout. This will result in a decrease in volume and weight, and a possible increase in reliability. The increase in reliability by using micrologic is due to the reduction in the number of elements used and assembly steps required to fabricate the unit. The delivery schedule of the first article is expected to improve by approximately two months as a result of this redesign. A further improvement in delivery with each subsequent article is anticipated due to reduction in manufacturing time required for the new design.

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The redesigned computer will occupy about 1.2 cubic feet, will weigh approximately 58 pounds and will require 80 watts of power for operation.

Development of Aerospace Ground Equipment (AGE) for the computer and fabrication of AGE breadboard models is progressing on schedule.

The first gyro was assembled in November 1962, and is now undergoing final test and calibration. On-schedule delivery of this first unit is anticipated in February 1963.

The second design release was made on December 1, 1962, and included the prealignment package. Installation of this assembly was originally planned under the systems contract, NAS 9-497, but was found to be more efficient and economical under the gyro contract.

The first three accelerometers have been delivered to Massachusetts Institute of Technology Instrumentation Laboratory for final test and calibration. Design problems have caused the release of the second group plus subsequent deliveries to be rescheduled six weeks.

A Massachusetts Institute of Technology study group was implemented to work with the MSC to establish requirements for the Spacecraft Pre-launch Automatic Checkout Equipment (PACE-S/C) computer program. Several NASA-Massachusetts Institute of Technology-North America Aviation, Inc., coordination meetings have been held on this subject to determine mutual requirements and responsibilities. Measurement lists for PACE-S/C checkout data were also established at these coordination meetings.

AGE requirements and schedules for checkout of the Guidance and Navigation System prior to spacecraft installation and for bench maintenance of the guidance and navigation subsystems were established and incorporated in Work Statements sent to the Massachusetts Institute of Technology's Industrial Support Contractors.

Mechanization drawing releases for Guidance and Navigation System AGE were initiated in December 1962, and are to be complete by March 15, 1963. Guidance and Navigation System AGE design specifications were released to the MSC on December 21, 1962.

Stabilization and Control System

A cost and usage review of the Stabilization and Control System resulted in the following configurational changes and confirmations:

- a. The horizon scanner and sun seeker were deleted.

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b. The euler angle generator was deleted and a simpler attitude gyro coupler unit was substituted.

c. The Stabilization and Control System will be a 400-cycle system with d-c summing.

d. The flight director attitude indicator (eight-ball) will be designed for 400-cycle operation and its interface with the Guidance and Navigation System will be by standard demodulation-modulation techniques.

e. The orbit rate switch will be retained.

f. The Service Module Propulsion System engine gimbal actuator feedback will be demodulated to eliminate a modulator in the actuator input.

g. The Service Module Reaction Control System engines will be 100-pound thrusters.

h. The Reaction Control System thrusters of the Command and Service Modules will use single automatic driver coils that are electrically similar thereby allowing a single driver package to service both. Separate manual coils will be provided.

The attitude gyro package mounting and cooling provisions have been firmed. A slide-in package configuration was chosen to simplify gyro in-flight replacement. Gyro drawings were released and two laboratory models have been built and are under test.

The rate gyro package mounting provision has been finalized as a slide-in configuration with removable gyro modules. Preliminary layouts are in progress and the gyro drawings have been released.

The accelerometer package drawings have been released.

Space allocation and mountings for the Electronic Control Assemblies including the Attitude Gyro Coupler Unit have been determined. Circuits are now being developed and temperature studies are being conducted on breadboard circuits. A vibration model of the mechanical mounting plate for the Attitude Gyro Coupling Unit is under construction. The attitude gyro package electronics are 40 percent breadboarded, the temperature control is 85 percent breadboarded, the pre-amplifier is 80 percent breadboarded, the accelerometer electronics are 100 percent breadboarded. Total system breadboard is 35 percent complete.

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A working model of the flight director attitude indicator is undergoing laboratory tests to simplify parts and assembly. Vibration tests are also underway on this unit.

Meter movements for the Gimbal Position Indicator are undergoing laboratory vibration tests.

The design specifications have been released for the ΔV indicator.

Manual controls are in the mock-up stage and under evaluation for configuration and mounting provisions. Tests are being conducted on switch types for inclusion within the manual controllers. Tests to-date indicate a need for hermetically sealed switches.

North American Aviation, Inc., and Massachusetts Institute of Technology have agreed to Service Module engine gimbal actuation and response requirements which are: Nozzle deflection $\pm 8.5^\circ$; nozzle angular rate 0.35 rad/sec; nozzle acceleration 3.5 rad/sec^2 ; and nozzle servo (outer loop) bandwidth 30 rad/sec.

A minimum navigational sighting rate of 1.2 arc min/sec ($0.02^\circ/\text{sec}$) has been established by the MSC, Massachusetts Institute of Technology and North American Aviation, Inc. The MSC, North American Aviation, Inc., and Massachusetts Institute of Technology have agreed on the lower equipment bay and panel configuration. Three-view drawings have been prepared.

The following is the stabilization and control subsystem schedule status:

- a. Rate gyro package - Gyro drawings are released and the first production package will be available in April 1963.
- b. Attitude gyro package - Drawings are released and the first production gyros are due in April 1963.
- c. Accelerometer package - Drawings are released and the first production package is due in June 1963.
- d. Electronics Control Assembly - Engineering breadboard model should be complete in February 1963.
- e. Attitude Gyro Coupling Unit - Preliminary design is complete and working model is due in January 1963.
- f. Controls and Displays - Drawing release is due in April 1963.

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The following is the Stabilization and Control System schedule status:

- a. Minneapolis-Honeywell Regulator Co., (in-house) should complete the system breadboard in April 1963.
- b. North American Aviation, Inc., should complete the system breadboard by May 1963.
- c. First prototype system is due for completion in June 1963.

The Minneapolis-Honeywell letter subcontract for the Stabilization and Control System was suspended by North American Aviation, Inc., on October 10, 1962, and amended in accordance with the current design concept. Negotiations on the new Statement of Work were completed by North American Aviation, Inc., and Minneapolis-Honeywell Regulator Co., on December 17, 1962. The new Statement of Work uses the current system status as the reference for a definitive contract. The Minneapolis-Honeywell Regulator Co., cost proposal and design specifications based on the new Statement of Work were submitted to North American Aviation, Inc., on December 26, 1962. The MSC is reviewing the new Stabilization and Control System Statement of Work and Procurement Specification with a target approval date of February 1, 1963. The North American Aviation, Inc., target date for the Minneapolis-Honeywell Regulator Co., definitive contract is February 10, 1963.

Reaction Control System

The design of the propellant feed systems for both the Command and Service Modules Reaction Control System (RCS) is proceeding essentially on schedule. The majority of the procurement specifications for the feed system components were released as of November 15, 1962. Proposals for the development and fabrication of tanks and positive expulsion devices are being evaluated.

The installation procedures for the Command Module RCS engine (GEMINI Orbit Attitude Maneuvering System engine) is being reviewed by North American Aviation, Inc., with the objectives of reduced installation complexity plus a reduction in the installed weight. The engine area ratio and, also the exhaust port area through the heat shield may be substantially reduced if this review is favorable.

The Service Module RCS engine has demonstrated a specific impulse of 303 seconds under simulated altitude conditions. Minimum impulse bits of less than the initially required 1 lb-sec have also been demonstrated. The subcontractor has accepted a revised minimum impulse

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bit requirement of 0.65 lb-sec, which will permit the RCS to satisfy the low roll rate requirement during navigational sightings. Simplified driver circuits and propellant valve arrangements are currently under investigation. The results of the valve investigation should be available by mid-January, 1963.

A recalculation of the RCS propulsion requirement for spacecraft maneuvering resulted in the reduction of fuel from 965 pounds to 700 pounds.

As a result of the current shortage of monomethylhydrazine, the Service Module RCS fuel was changed to a 50-50 blend of N_2H_4 and UDMH. This change did not affect the development effort on the Service Module RCS engine. The Command Module RCS will continue to use monomethylhydrazine, making use of a limited supply on hand until monomethylhydrazine production is resumed.

Phase I of the RCS Jet Plume Test at Arnold Engineering Development Center, which is cell checkout and test fixture installation, is underway. Phase II, which is APOLLO hardware testing, is expected to start in mid-February, 1963. A pre-prototype Service Module RCS engine is on-hand at Arnold Engineering Development Center and has undergone preliminary tests in connection with cell checkout.

Cold-flow tests on the breadboard model of the RCS are scheduled to begin in January 1963. Four pre-prototype engines have been delivered for these tests.

Service Module Propulsion System

Firings were made on unbaffled aluminum injectors to evaluate performance, stability, and injector face cooling. One injector has accumulated 1300 seconds of operation. Some patterns were stable until instability was induced by firing a solid charge into the chamber. A modified Titan injector with five baffles was fired and is the most stable configuration tested to date. A five-baffle aluminum injector is being fabricated. One ablative chamber was fired for 900 seconds without significant evidence of throat erosion.

Three 2200-pound thrust sub-scale engines were fired at simulated altitude conditions at Arnold Engineering Development Center. All three engines operated for 750 seconds of firing during simulated mission profiles. Buckling of the radiation-cooled nozzle extension occurred on all engines, because of the excessive temperatures encountered at the chamber flange location. Additional simulated altitude testing is scheduled for January 1963.

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The propellant quantity gaging and propellant utilization system has been changed from a closed loop (automatic) system to a system of propellant quantity gaging with a crew display of quantity remaining and a manually-operated flow control valve.

The procurement specifications for the Service Module Propulsion System propellant tanks have been completed and nine companies have responded to the Request for Proposal.

Communications System

Principal subcontract awards for components to the Communication System have been made to Radiation, Inc., for the Pulse Code Modulation Telemetry equipment; to Motorola for Deep Space Instrument Facility Transponder; and to ACF Industries, Incorporated, for C-Band Transponder.

The December revised statement of work for Communication and Data Subsystems is being negotiated with Collins Radio Company. This revised statement of work will reduce the Collins Radio Company effort and effect a cost reduction.

North American Aviation, Inc., is recommending direct procurement of the television system rather than subcontracting through Collins Radio Company. The MSC has not as yet taken a position on this item.

Electrical characteristics of the personal communication system (space suit telemetry and voice communication) has been defined. Physiological data will be transmitted by FM/AM over seven subcarriers, one providing 30-cycle response and six providing two-cycle response. Voice will be amplitude modulated.

Operational Instrumentation System

Collins Radio Company has awarded the data storage equipment contract to Leach Corporation, Azusa, California.

North American Aviation, Inc., has scheduled the award of the spacecraft central timing equipment contract for January 1, 1963.

The signal conditioning and data patch-panel equipment will be manufactured by Collins Radio Company.

Transducer equipment will be procured by North American Aviation, Inc.

Detailed delivery schedules on some operational instrumentation for airframe APOLLO spacecraft have been released to the MSC. Complete

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design and development schedules on the operational instrumentation should be available from North American Aviation, Inc., in January 1963.

Electrical Power System

A recalculation of the Command Module and Service Module electrical loads indicates the following: The total energy required from prelaunch until reentry is 530 kilowatt hours. The average normal power required is 1578 watts and the average emergency power required is 1200 watts. During entry and recovery the average normal power load is 665 watts and the average emergency power load is 540 watts. The post-landing average normal power load is 24 watts and the average emergency power load is 14 watts. The above loads are within the capacity of the fuel cell and battery systems.

The silver-zinc battery system, which will supply all electrical loads following separation of the Service Module, has been modified as follows: One battery has the capacity to supply all entry and recovery loads. Two batteries will be required to supply post-landing loads. Two batteries will supply pyrotechnic loads. One battery charger will be available to recharge the batteries from the fuel cell power supply. A system for venting batteries overboard is being considered.

The Electrical Power System space radiator has two panels, totaling 45 square feet.

Schedules for the design, fabrication, test, and delivery of batteries, inverters, and sequencers are current and will present no delivery problem.

Schedules for fuel cell deliveries were changed approximately 30 days by Pratt & Whitney's November 15, 1962, Cost Proposal. Initial delivery of three modules is now scheduled for June 1963.

Although the A-2 and 31-cell stack tests were started on schedule in early October, a mid-October failure caused shut-down and minor redesign. The test is expected to restart on December 28, 1962. Independent module tests, scheduled to start November 1, 1962, were delayed until December 19, 1962. This test was terminated almost immediately after starting in December due to loss of electrolyte through the oxygen electrode. Investigation of the cause of and corrective action for this failure is now underway.

Two additional 31-cell stacks and a second 31-cell module will be completed and ready for development tests in early January 1963.

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Earth Landing System

Nine parachute test drops were made at El Centro, California. Eight of these drops were single main parachute tests and one was a parachute test vehicle systems test with a cluster of three main parachutes.

Of the 16 single main developmental parachute drops to date, 11 have been successful. Of the 5 unsuccessful test drops, 4 were with a "light weight" canopy for the purpose of investigating possible weight reduction. The remaining unsuccessful single main test was a result of a failure in the vent area at the pilot parachute attach point. A design change was made and proof tested successfully.

The Project APOLLO 88.1-foot Do Ringsail parachute is presently being developed to accept maximum disreef loads with one parachute at Command Module design weight prior to the time for the second main parachute to disreef. This strength increase is required due to:

- a. Reefing cutter time tolerances relative to ringsail parachute disreef opening times.
- b. Difference in time at main parachute line stretch due to pilot parachute deployment at attitudes up to $\pm 30^\circ$.
- c. The aerodynamic characteristic of the ringsail parachute in a cluster appears, from available data, to result in uneven filling in the reefed and disreef states.

The drogue parachute wind tunnel tests in the North American Aviation, Inc., low speed tunnel have been completed, and tests will soon begin in the Langley Research Center variable density tunnel.

Eight impact tests have been conducted at North American Aviation, Inc., during this reporting period which make a total of nine to-date. All tests have been conducted at approximately 23 fps vertical velocity using temporary facilities. There have been five drops into water, two on asphalt, and two on soil. Three tests were conducted with a horizontal velocity of 20 fps and 25 fps on asphalt and 25 fps on soil. The boilerplate tumbled at 25 fps on asphalt and soil.

Impact tests of the one-quarter scale model into sand at Langley Research Center are complete. Drop tests into water are currently being conducted. Results and correlation with full-scale data are pending better soil classification.

ADAPTER

There have been no major changes in the basic structural configuration of the spacecraft-launch vehicle adapters.

The C-1 adapter structural drawings are 80 percent released. Release of the remaining 20 percent is being held up pending redesign of the adapter for C-5 loads. Approximately 25 percent of the drawings will be affected by the redesign requirement.

The C-5 adapter is still in the early predesign stages and no drawings have been released. Coordination with the Lunar Excursion Module Contractor is necessary before drawings can be released and this coordination will begin in January 1963.

LUNAR EXCURSION MODULE

The Lunar Excursion Module serves as a shuttle vehicle for transferring two of the three crew members and their payload from the Command Module in lunar orbit to the lunar surface and then return them to the Command Module. Included in this operation are the functions of separation from the Command Module, lunar descent, lunar landing, ascent, and rendezvous and docking with the Command Module.

Grumman Aircraft Engineering Corporation was selected for negotiation of a contract to develop the Lunar Excursion Module on November 7, 1962. Starting on November 19, 1962, a team of approximately 100 Grumman Aircraft Engineering Corporation and MSC personnel initiated an effort to accomplish the following objectives:

- a. Definitize a contract for the Lunar Excursion Module Program
- b. Review subcontracting plans
- c. Determine an agreed upon technical approach and initial effort
- d. Define operating procedures.

The definitization of the contract involved negotiating an agreement on the effort required to carry out the program, the cost factors to be applied to the effort, the fee, and the contract including the Statement of Work and various clauses. Agreement was reached in all areas with a total contract cost of approximately 385 million dollars including approximately 25.3 million dollars of fee. The contract covers the

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manned lunar landing mission. The contract provides that there be no change in fee except for five specified items such as numbers of Lunar Excursion Modules to be developed, or changes outside the normal control of the Contractor.

The subcontracting plans of the Contractor were reviewed. In a number of cases the Contractor's recommended approach was changed from the proposal recommendation to allow the use of items already under development in the APOLLO Program. Final details of the subcontracting plans will be worked out in early January 1963.

A technical approach was agreed upon and documented in an exhibit to the contract. Additionally, the effort of the Contractor for the first several months of the contract was determined and documented. A list of priority items was also determined with estimated times for completion of these efforts.

The Contractor was provided with material relative to the operating procedures, including procedures for direction, coordination and reviews. These procedures will be further defined in forthcoming meetings between the Lunar Excursion Module contractor and other APOLLO contractors.

SPACE SUIT SYSTEMS

The contract for the Project APOLLO space suit was signed with Hamilton-Standard in October 1962. Hamilton-Standard will control the overall system design and will fabricate the portable life support system. International Latex Corporation will subcontract from Hamilton-Standard for design and fabrication of the pressure garment, coverall, helmet, gloves, and boots.

The entire space suit system will not be required during the first Project APOLLO manned suborbital flight; however, the pressure garment portion will be used for emergency decompression tests in December 1964, and is almost completely qualified at this time.

The space suit program objective is to be ready for an extravehicular experiment on the first manned orbital flight in March 1964. Such experiments will provide the final space suit qualification and operational demonstration.

Initial meetings of North American Aviation, Inc., and Hamilton-Standard personnel were held in November 1962.

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North American Aviation, Inc., has submitted preliminary designs of suit-spacecraft umbilicals. These designs are under review by the MSC and the suit contractors.

RESEARCH AND DEVELOPMENT INSTRUMENTATION/COMMUNICATIONS SYSTEM

Command receivers/decoders have been deleted from the Project APOLLO Research and Development flights' instrumentation complements since no command requirements presently exist. However, units will be available if a requirement arises.

Part-by-part delivery schedules for Research and Development Instrumentation/Communications Systems for Project APOLLO Research and Development flight missions through A-103 have been established. These delivery schedules are based on many contingencies and proposed handling procedures for the various equipments.

All NASA-furnished instrumentation/communications equipment for the May 1963, Pad Abort Mission (PA-1) will be delivered to North American Aviation, Inc., by the end of December 1962. The system breadboard will also be furnished to North American Aviation, Inc., this time.

The sequencer and antennas are the only items of the Research and Development Instrumentation/Communications System that are provided by North American Aviation, Inc. The sequencer and antennas for the PA-1 mission will be available late in January 1963.

SCIENTIFIC INSTRUMENTATION

Investigation has continued into types of scientific experiments which will be conducted on lunar flights. In addition, coordination is being established between the MSC and other interested NASA organizations. All scientific instrumentation will be government-furnished equipment. Preliminary drafts of a Statement of Work and a Procurement Plan for scientific instrumentation are being prepared and, as firm requirements are established, these drafts will be finalized and implemented.

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WEIGHT

The APOLLO Spacecraft weights are shown below. A weight apportionment has been made based on an assumed 90,000-pound payload performance capability of the Saturn C-5. This weight is termed a design allowable. A lower target weight for each module has been assigned. Achievement of the target weight will allow for increased fuel loading and therefore greater operational flexibility and mission reliability (Table I). The Service Module propellant tanks have been sized to take advantage of achieving target weights or increased C-5 performance over 90,000 pounds.

TABLE I

	Design Allowable	Current	Target
Command Module	9,500	9,350	8,500
Service Module (includes trapped or unused propellant	11,500	10,205	11,000
Adapter to S-IVB	<u>3,000</u>	<u>3,260</u>	<u>3,000</u>
Total	24,000	22,815	22,500
Service Module Useful Propellant	<u>40,500</u>	<u>34,710</u>	<u>34,240</u>
Total	64,500	57,525	56,740
Lunar Excursion Module	<u>25,500</u>	<u>21,500</u>	<u>21,500</u>
Total	<u>90,000</u>	<u>79,025</u>	<u>78,240</u>

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Additional detailed analysis of the Command Module and Service Module, particularly in the structure, has resulted in a considerable weight change. Several proposals are being investigated which have good potential for weight reductions.

FLIGHT TECHNOLOGY

Mission Natural Environment

An examination of the micrometeoroid environment criteria has recently been concluded, and as a result, a revised micrometeoroid environment was agreed upon. This environment retains the Whipple visual magnitude versus flux relationship and the corresponding velocities. Ten percent of the flux, however, has been designated as stoney asteroidal meteoroids with a density of 3.5 gram/cm^{-3} while the other 90 percent of the flux has been attributed to the dust-ball cometary type meteoroids with a 0.5 gram/cm^{-3} density. Attempts are now being made to include this revised environment in the Lunar Excursion Module Statement of Work.

An evaluation of the radiation doses encountered while traversing the artificial, trapped-radiation belt has also been concluded. This evaluation, made from reference 2, "The Artificial Radiation Belt", indicates that no significant radiation dose will be encountered. It should be pointed out, however, that any future high altitude nuclear detonations will change the intensities of this belt.

A natural environment notebook is being compiled which will be used as a single source for natural environment criteria as it pertains to the Project APOLLO mission.

Performance

A reduction in the Service Module Reaction Control System fuel requirement from 965 pounds to 700 pounds has been made. The major reason for this reduction was a complete recalculation of RCS propulsion requirement for spacecraft maneuvering.

In addition, the Command Module RCS fuel requirements have been estimated to be 102 pounds in each of two independent systems. This value was based on extensive simulation studies of controlled reentry.

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Spacecraft Dynamics

A "turnaround" maneuver is required after non-tumbling aborts to orient the Command Module with blunt face forward and thereby permit the removal of the apex cover and deployment of the main parachutes. Because of the existence of an apex-forward trim point, the Command Module could not be reoriented by the RCS at dynamic pressures greater than 20 pounds per square foot. North American Aviation, Inc., has recommended the addition of longitudinal strakes on the Command Module in the X-Y plane to eliminate this trim point hypersonically and supersonically. Addition of the strakes will not eliminate the trim point subsonically, but will increase the trim angle-of-attack to approximately 70°, thereby allowing successful jettison of the apex cover. Drogue parachute deployment could then be achieved with the drogue parachute accomplishing Command Module turnaround.

Aerodynamics

Aerodynamic characteristics of the various APOLLO spacecraft configurations were generally defined in the calendar year 1962 wind tunnel program. Changes in configuration details since the beginning of the program now dictate a second series of tests, using updated models. The MSC approved the proposed calendar year 1963 program in December. The first half of calendar year 1963 will be devoted to confirmation of the present spacecraft design prior to 100 percent drawing release in May. Subsequent to the 100 percent drawing release, the wind tunnel program will evaluate the production configuration.

Limited data on the static stability of the launch escape configuration with the escape rocket burning were obtained using a hydrogen peroxide "hot-jet" model in the Langley Research Center 16-foot tunnel. The catalyst pack was accomplishing successful decomposition of the hydrogen peroxide when the model suffered a structural failure. The test technique has proved feasible, and testing will continue upon completion of model repair in late January 1963.

Noise and buffet encountered by the spacecraft during the launch environment are currently being analyzed, based on test data obtained from the PSTL-1 fluctuating pressure wind tunnel model of the Project APOLLO/Saturn C-1 configuration.

Aerodynamic Heat Transfer

Experimental investigations of the reentry vehicle heating rate distributions have continued. The following heat transfer wind tunnel tests were completed.

- a. Tests in the Arnold Engineering Development Center (Mach number range 8) "B" and (Mach number range 10) "C" facilities on a 0.045 scale model of the Command Module with detachable Service Module and escape tower.
- b. Test in the Arnold Engineering Development Center HS-II (Mach number range of 16 to 21) facility on a 0.40-scale model of the Command Module.
- c. Test in the Arnold Engineering Development Center (Mach number range 10) "C" facility on a 0.045 scale model of the forward portion of the spacecraft and the launch vehicle.

A review is being made of the estimated reentry heating loads used in the Project APOLLO heat shield design as a result of data obtained from the Langley Research Center. These data indicate the present estimates of the reentry heating loads may be overly conservative. NASA Research Centers are assisting in this review and a summary meeting will be held in January 1963.

Ablation Material Thermal Performance

The preliminary experimental investigation of the performance of the alternate heat shield ablation materials has been completed. The results of this program were sufficiently encouraging to warrant a more detailed investigation. North American Aviation, Inc., was instructed to conduct more detailed investigations of the thermal, mechanical and fabrication characteristics of alternate materials. This program began in November 1962, and will be completed by February 1963. The results of this intensive investigation will provide sufficient engineering data on which to base a selection of the ablation material and fabrication technique most applicable to Project APOLLO.

In conjunction with this program, AVCO has developed a low density, honeycomb-filled material which appears to offer several thermal and mechanical advantages over their original approach.

Engineering Simulation Program

The overall engineering simulation program planned by North American Aviation, Inc., has been presented to NASA. The program includes three evaluators, one partially complete simulator, and one full simulator. The program will require a peak analog computer usage of 2000 amplifiers and a full 7094 digital computer.

Simulations completed during this quarter include docking in lunar orbit.

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Transposition and Docking

North American Aviation, Inc., completed and submitted preliminary reports of a transposition and docking study. The study analyzed three docking modes, (free fly around, mechanical arm, and tethered flight) and concluded with a recommendation favoring the free fly around.

RELIABILITY

An "APOLLO Reliability Program Requirements for Manned Spacecraft Contractors" documents was prepared to define standardized reliability approach for the APOLLO Program. The document emphasizes the relationship to other contractors, basic reliability concepts, program planning and management, reliability analysis, test program, document submission requirements and format. The requirements of the document are being discussed with the major Project APOLLO contractors for implementation.

Command and Service Module - North American Aviation, Incorporated

A series of meetings has been initiated between North American Aviation, Inc., and their subcontractors to direct them as to specific Project APOLLO reliability requirements.

North American Aviation, Inc., has defined their qualification program for the entire Command and Service Module development. Hardware utilization requirements were delineated for all subsystems of the qualification program. The minimum hardware utilization requirements for the qualification program as proposed by North American Aviation, Inc., were four equivalent subsystems plus replacements on critical and limited life items. A reliability test program is not contemplated, but reliability assessment data will be available as a by-product of all testing.

Navigation and Guidance System Development - Massachusetts Institute of Technology

Reliability Statement of Work inputs have been provided for use in contractual negotiations with the Massachusetts Institute of Technology-Instrumentation Laboratory Industrial Support Contractors.

Lunar Excursion Module Development - Grumman Aircraft Engineering Company

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The reliability and quality assurance portions of the Grumman Aircraft Engineering Company cost proposal were reviewed in preparation for formal contract negotiations.

SPACECRAFT-LAUNCH VEHICLE INTEGRATION

The five Manned Spacecraft Center-Marshall Space Flight Center-Launch Operations Center coordination panels have conducted several meetings to effect the integration of the spacecraft to the launch vehicle and its associated launch and flight control AGE. The following accomplishments are noted.

a. General - The MSC membership and panel procedures have been changed to strengthen the effectiveness of the panels.

b. Mechanical Integration Panel - The environmental control requirements for SA-6 have been defined. Mechanical interface requirements between the Service Module, adapter, and S-IVB stage instrument unit for SA-6 and SA-7 space vehicles have been established.

c. Flight Mechanics, Dynamics and Control Panel

(1) The official performance data for the C-1, C-1B, and C-5 operational vehicles was approved by the Marshall Space Flight Center Weight and Performance Review Board for official transmittal to MSC.

(2) The MSC and Marshall Space Flight Center have agreed that the S-IVB stage will not provide ullage for the Service Module.

(3) The MSC agreed that the booster pitch and roll maneuvers for all Saturn launch vehicles will have no adverse effect on the spacecraft.

(4) The MSC requires no boost trajectory shaping for alleviation of reentry loads or for increasing the landing footprint.

(5) A Guidance Implementation Sub-Panel has been established within the panel to define the interface between the MSC and the Marshall Space Flight Center guidance systems in the event that redundant guidance capability is required once the space vehicle is in earth orbit.

d. Instrumentation and Communications Panel - The Marshall Space Flight Center agreed to supply the Q-balls to be installed by North

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American Aviation, Inc., for all C-1 research and development tests.. On SA-6 the "Q-ball" will be powered and telemetered from the instrument unit of the S-IVB stage. An agreement has been reached on the range of the bending moment measurements on the spacecraft for space vehicles SA-6 through SA-10, however, the locations of the sensors are still under investigation.

e. Launch Operations Panel

(1) SA-6 with Boilerplate 13 will contain no explosives or propellants except for the Launch Escape System jettison equipment. Umbilical ejection for Boilerplate 13 will occur at S-IC stage ignition. A provision will be made for shut-down of spacecraft power in the event of a scrub between ignition and lift-off.

(2) Responsibility for cables, junction boxes, spacecraft-peculiar coolant system and installation of miscellaneous feed lines have been agreed upon between MSC and Marshall Space Flight Center.

(3) A simplified egress operating requirement was established by the MSC for all complexes.

(4) Spacecraft transporter dimensions have been specified and are satisfactory for Cape Canaveral operations.

(5) The communication system tie-in between Complex 37 and 34 will be compatible with the Merritt Island spacecraft facility and will be provided by the Launch Operations Center subject to approval of the Preflight Operations Division of MSC.

(6) The Launch Operations Center has been advised of the spacecraft propellant requirements and will provide propellant and associated services as required in support of the MSC.

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MANUFACTURING

Phasing charts showing the schedules for the manufacture and delivery of ground and flight test articles being produced by North American Aviation, Inc., have been developed.

MOCK-UPS

All North American Aviation, Inc., mock-ups were planned for completion prior to December 30, 1962. However, only the following mock-ups were completed by December 30, 1962:

- M-2 Command Module cabin interior arrangement
- M-3 Command Module for MSC
- M-4 Partial Service Module and partial adapter
- M-5 Command Module for exterior equipment
- M-7 Complete Service Module
- M-9 }
and } Command and Service Modules, adapter, and Launch
M-11 } Escape System for handling and transportation
- M-12 Partial Command Module
- M-18 Command Module, Service Module, adapter and Launch
 Escape System

BOILERPLATES

Ground Tests

Manufacture of Boilerplate 19 was completed on schedule. Some delay was experienced during assembly and installation of equipment in Boilerplates 2 and 3; however, both articles were completed during

December. Boilerplates 3 and 19 are being delivered to Northrop-Ventura for the parachute drop tests. Boilerplate 2 will be used by North American Aviation, Inc., for the land and water impact tests already in progress on Boilerplate 1.

Flight Tests

Manufacture of Boilerplate 6, for the pad abort test (PA-1), is underway. Redesign of the launch escape tower has delayed delivery of the tower for Boilerplate 6, however, the tower will be delivered and installed out of station in order to meet the scheduled delivery date to White Sands Missile Range. The pad abort test with Boilerplate 6 is scheduled for May 15, 1963.

AIRFRAMES

Fabrication of detail parts for the first airframe (AFRM-001) is underway. Assembly is scheduled to begin in March 1963, and completion of the assembly operation is scheduled for October 1963. Systems installation and checkout is planned based on a delivery of the Service Module to White Sands Missile Range in February 1964, and delivery of the Command Module to White Sands Missile Range in May 1964. AFRM-001 will be used for propulsion development testing.

QUALITY ASSURANCE

Quality Assurance documentation formats are being finalized for use by all Project APOLLO contractors, either in the original preparation of their Quality Control Program Plan or in its later revision. By means of these formats, uniform program plans will be prepared, thereby assuring easier determination of their adequacy.

A follow-up of the earlier NPC 200-1 familiarization meeting held at North American Aviation, Inc., is underway with Department of Defense Government inspection personnel. An inspection plan has been submitted by the Air Force Government Inspection Office at Aerojet-General Corporation, for the Service Module Propulsion System motor.

Field service functions in support of NASA at Aerojet-General Corporation, Sacramento, California, have been delegated to the Department of the Navy, BUWEPS, at Sacramento, California.

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The Marshall Space Flight Center specification for soldering of electrical connections, MSFC-PROC-158A has been evaluated and amended for application to the APOLLO Program. The amended specification has been transmitted to North American Aviation, Inc., for preliminary cost estimating purposes.

Specific activities include:

- (a) Boilerplates 3 and 19 were inspected and approved.
 - (b) Final inspection of mock-ups 5 and 12 was completed by the MSC and North American Aviation, Inc.
 - (c) A detailed review of Aerojet-General Corporation, Quality Control procedures was made and NPC 200-2 was implemented without major change in the established procedures.
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CREW TRAINING

Currently approved training equipment includes mission simulators and a single part-task trainer.

The Request for Proposal on the mission simulator was released December 8, 1962; proposals are due on January 7, 1963, with contract award in March 1963. Seven bidders are competing for the contract: ACF Industries, Inc., Curtiss-Wright Corporation, McDonnell Aircraft Corporation, Minneapolis-Honeywell Regulator Company, Link Division, General Precision, Inc., Goodyear Aircraft Corporation and Melpar, Incorporated.

The three originally planned part-task trainers were consolidated into a single training device. This trainer will provide training for the mission segments in which the crew is most active. It will also allow proficiency training in particular tasks. The trainer will consist of a simulated Command Module, an instructor's console and a hybrid (digital-analog) computer complex. North American Aviation, Inc., has submitted a preliminary engineering development report describing the part task trainer. This report is currently being revised by NASA. Target dates are:

North American Aviation, Inc., go-ahead . . . February 1963

Design Freeze July 1963

Delivery March 1964

The new flight crew personnel are being familiarized with Project APOLLO. This familiarization consists of a briefing on Project APOLLO by the Flight Crew Operations Division; a visit to Marshall Space Flight Center for briefings on the Saturn C-1, C-1B, and C-5 boosters; visits to North American Aviation, Inc., for a briefing on the APOLLO Spacecraft and the S-II booster development; and to Douglas Aircraft Corp., a briefing on the S-IV and S-IVB development.

OPERATIONS

SPACECRAFT CHECKOUT

A general spacecraft checkout philosophy and plan for accomplishment has been established. A tentative measurement list has been developed and work has started on the sequencing of the various checkout operations. Decisions have been made on the amount of checkout equipment which will be part of flight hardware and the amount which will carry-on equipment. The functional and equipment interfaces between the inflight test equipment and the Spacecraft Preflight Automatic Checkout Equipment (PACE-S/C) equipment are currently being studied. The checkout interfaces between the Command and Service Modules and the Lunar Excursion Module are also being studied.

The AGE provisioning plan has been established and is being negotiated with North American Aviation, Inc., and Grumman Aircraft Engineering Corporation. At the end of this reporting period, some 148 different models of AGE representing 360 separate pieces of equipment have been approved for release at North American Aviation, Inc.

PREFLIGHT

The development of the PACE-S/C ground stations is on schedule. North American Aviation, Inc., has requested a breadboarded PACE-S/C ground station to be at their facility by September 1963, for use with inhouse spacecraft.

FLIGHT

Under contract NAS 9-366, the Western Development Laboratory of Philco Corp., developed preliminary documents on the Project APOLLO network performance requirements and Project APOLLO data flow. More comprehensive concepts are due in the supplementary issues of these documents in early 1963.

The proposals for the Integrated Mission Control Center (IMCC) were received on December 10, 1962. Prospective contractors submitted proposals which are under evaluation by representatives from the MSC

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and Headquarters. Contract award is tentatively scheduled for early in 1963.

A letter contract was given to International Business Machines Corporation on December 6, 1962, to begin work on the Real Time Computing Center (RTCC) in support of the MSC projects. An International Business Machines project group has been set up in Houston, Texas and work has been initiated on the RTCC complex and computer programs. International Business Machines will be used in an associate contractor role to the IMCC contractor.

The Lincoln Laboratory of Massachusetts Institute of Technology has completed most of the phases required to initiate studies of on-site data processing. Initial results of this study program are scheduled for early in 1963.

A Deep Space Instrument Facility - type transponder is scheduled for the first Project APOLLO manned mission. The ground installation for evaluation of its use in the earth orbital missions is under study.

The Project APOLLO data network requirements document for C-1 missions is scheduled for formal issue by January 1963. This document defines the data network support required for the C-1 missions.

North American Aviation, Inc., has begun work in support of mission operations in conjunction with the MSC.

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GROUND TEST PROGRAM

The ground spacecraft-propulsion test program will be conducted to verify the performance of the propulsion system with design specifications and to evaluate the interactions of the related spacecraft systems in conjunction with the propulsion system. Captive firing tests will be performed on two test stands located at the Project APOLLO Propulsion System Development Facility at White Sands Missile Range. The test vehicles initially scheduled for this program are Test Fixture F-2 on Test Stand I and AFRM-001 on Test Stand II.

Present planning requires the completion of Test Stand I by mid-September, 1963, with testing of the F-2 Fixture to begin right after checkout. Testing of AFRM-001 Service Module is scheduled to begin in March 1964.

A review of the A-E Design Criteria for the White Sands Missile Range is currently being completed along with the review for the safety plans for the manned-mated operation tests of AFRM-001.

APOLLO TEST STAND I

Test Fixture F-2 will be tested at the Project APOLLO Test Stand I Propulsion System Development Facility. The F-2 will be of "battleship" construction, simulating the Service Module Propulsion System flight hardware. Plumbing and valving will be replaced with spacecraft hardware as parts become available. Structural steel will be used to provide tankage support, stand tie-down, and engine mounting. The Service Module Propulsion System engine will initially be a prequalified spacecraft engine with operable gimbal mechanism. Qualified engines will be used when they become available. The expansion nozzle will be removed from the thrust chambers for the near-sea-level operations. The Project APOLLO AGE which pertains to the F-2 Fixture are checkout and control, handling, and service equipment. Specific AGE lists are currently being finalized.

The purpose of the F-2 Fixture test program is to obtain data from which an evaluation of the Service Module Propulsion System can be accomplished under normal and off-limits conditions. Investigations of problems and/or malfunctions experienced on test and flight vehicles will be conducted with this test fixture. Also, the F-2 test program will continue to accumulate reliability statistics in support of the spacecraft propulsion program.

APOLLO TEST STAND II

The spacecraft propulsion test program will be conducted on AFRM-001 at Test Stand II. AFRM-001 is an actual Command Module and Service Module equipped with the necessary flight configured systems. Related spacecraft systems will include: Stabilization and Control, Control and Display, Electrical Power Supply, Guidance and Navigation, Telemetry, and In-Flight Test. However, the exact configuration and utilization of the Guidance and Navigation, Telemetry, and In-Flight Test systems planned for AFRM-001 are not firm at this time.

Static firing tests will be performed with the Service Module Propulsion System and with the Command and Service Module Reaction Control Systems in their flight configuration. The first operational tests of the Electrical Power System with the fuel cells and their associated cryogenic system will be conducted on AFRM-001. The propulsion data obtained from these tests will be used to investigate start-stop transients, system response, and repeatability for normal and malfunction mode operations. Mission profile tests will be conducted in simulation of high altitude abort, earth orbital, circumlunar, lunar orbital, and translunar abort.

Tests that are considered hazardous to AFRM-001 will first be conducted on Test Stand I using test fixture F-2.

FLIGHT TEST PROGRAM

The tentative Project APOLLO mission schedule is shown in figure 3. Preliminary data for Project APOLLO flights, using the Saturn C-1 launch vehicle, is under development through the second manned flight. Revisions to the flight test program will be presented in the next status report. Launch exit environment, structural qualification, demonstration of separation systems and flight qualification of the crew safety system requirements can also be met as secondary objectives during the Saturn launch vehicle development flights.

The flight testing at White Sands Missile Range can be divided into three general categories: pad aborts, in-flight aborts off a Little Joe II launch vehicle and Lunar Excursion Module tests. Planning for the Lunar Excursion Module portion of these operations is still in the preliminary stage.

PAD ABORTS

a. First pad abort - Pad abort, APOLLO Mission PA-I, will be the first flight test of the Project APOLLO escape configuration. The test configuration will consist of a prototype Launch Escape System and a boilerplate Command Module (Boilerplate 6). The primary purpose of this test will be to determine the stability characteristics of the APOLLO escape configuration and the operational characteristics of the escape system during a pad abort. The actual running of this test is scheduled for mid-May, 1963, at White Sands Missile Range.

Briefly, the flight plan will be as follows: During the final phase of the Pad Abort countdown, a ground command abort signal will be transmitted to the launch vehicle. Launch escape motor ignition will occur and the pitch control motor will be ignited. After a time interval, the apex heat shield will be jettisoned, and then the drogue parachute deployed. The drogue parachute orients the Command Module blunt end forward for main parachute deployment. After a time interval, the drogue parachute is released and the pilot parachute deploys the three main parachutes, which are inflated to a reefed condition to reduce the opening shock to the parachutes. After another time interval, the three main parachutes are disreefed, fully inflated and will at that time establish an equilibrium descent velocity of approximately 24 feet per second. The main parachutes are released upon earth impact of the Command Module.

The data recorded by the tracking, onboard tape recorder and telemetry will give information to:

(1) Determine the aerodynamic stability characteristics of the APOLLO escape configuration during a pad abort.

(2) Demonstrate the capability of the escape system to propel the spacecraft a safe distance from the launch vehicle during a pad abort.

In addition, escape tower vibration will be determined, and launch escape tower release mechanism operation, tower jettison motor operation and the parachute recovery system operation will be demonstrated during a pad abort.

The boilerplate spacecraft will be constructed of aluminum, and will consist of an aft bulkhead, a simulated heat shield, inner and side walls, forward bulkhead, and the crew compartment structure assembly.

b. Second Pad Abort - Pad Abort II will be a qualifying test for the Launch Escape System using a prototype Command Module (AFRM-010) with specified systems aboard. This test is scheduled for the first part of November 1964, at White Sands Missile Range.

Briefly, the configuration will consist of a Launch Escape System, a partial Command Module Communication and Instrumentation System plus an interim research and development communication and instrumentation system, Stabilization and Control System, Electrical Power System for the Command Module, Environmental Control System without the space suit circuit, and parachute recovery system. A heat shield will not be required.

A structure anchored to the pad will simulate the Service Module. An operational attach and release system will be incorporated between the Command Module and the simulated Service Module.

The flight plan will be the same for Pad Abort I. Data will be obtained from tracking, an onboard tape recorder, and telemetry. These data will be used to demonstrate the structural integrity of the spacecraft, subsystems, determine the abort and recovery sequence, and qualify the operation of the parachute recovery system.

LITTLE JOE II

a. High "q" - Project APOLLO Mission A-001 will be the first

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Little Joe II boosted development test of the Launch Escape System. The test configuration will consist of a prototype Launch Escape System, a boilerplate Command Module, a Command Module to Little Joe II adapter, and a Little Joe II launch vehicle.

The purpose of the test is to demonstrate the operation of the Launch Escape System at high dynamic pressure in the transonic speed range. Abort initiation will occur at about 20,000 ft. at Mach number 0.9 simulating a point on a nominal C-1 trajectory.

b. Airframe High "q" - Project APOLLO Mission A-003 will be a Little Joe II boosted development test of the Launch Escape System and a prototype airframe. It will be tested at conditions similar to those of Mission A-001, and will demonstrate the structural integrity of the Command Module under conditions of maximum dynamic pressure subsequent to abort.

c. Boilerplate High Altitude - Boilerplate 22 will be used to determine the adequacy of a high altitude abort. This test will be conducted at the White Sands Missile Range during the first part of May 1964, and will use a Little Joe II launch vehicle to simulate an abort from the Saturn C-1 launch vehicle prior to launch escape tower jettison.

The configuration of Boilerplate 22 will consist of a Launch Escape System, research and development (interim) communication and instrumentation system with onboard tape recorder, an interim Stabilization and Control System (rate stabilization only), Command Module Reaction Control System, interim Electrical Power System, and interim Environmental Control System (temperature control only). The Service Module will be simulated with a long adapter between the Command Module and Little Joe II. An operational Command and Service Module release mechanism will be used.

The data recorded by the tracking system, the onboard tape recorder and the telemetry system, will provide information for determining the aerodynamic stability characteristics of the spacecraft during a simulated Saturn C-1 launch just prior to tower Jettison, determine capability of the Reaction Control System to rate-stabilize the Command Module for reentry, demonstrate the capability of the launch system to propel the spacecraft to a safe distance from the launch vehicle just prior to tower jettison, and demonstrate the parachute recovery system.

An additional Little Joe II test vehicle is being procured for a spare. It will be capable of performing missions similar to PA-I or A-001 in the event of mission failure on one of these development tests.

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UNMANNED FLIGHTS

Flight qualification of the actual adapter and Service Module structure and spacecraft separation system will be accomplished on the fourth Saturn-Apollo C-1 launch vehicle in October 1964, approximately three months prior to the first manned flight.

The specific test objectives of the mission are to qualify the C-1 launch vehicle, qualify the physical and flight compatability of launch vehicle and spacecraft for manned flight, demonstrate the structural integrity of the spacecraft adapter and Service Module, and demonstrate the separation of the spacecraft from the launch vehicle following S-IVB stage burnout.

The spacecraft configuration for this flight is as follows:

- a. Command Module - Boilerplate 18
- b. Service Module - Airframe structure
- c. Adapter - Airframe structure
- d. Dummy Service Propulsion System bell
- e. Research and Development flight test instrumentation
- f. Electrical power and Research and Development Environmental Control System as required.
- g. Spacecraft adapter to S-IV stage and Service Module to adapter separation system.
- h. Spacecraft propulsion devices as required for normal spacecraft launch vehicle separation.
- i. Boilerplate Command Module ballast and Service Module ballast using tanks attached to Service Module hard points.

MANNED FLIGHT

The first manned flight (December 1964) will be a suborbital flight on a Saturn C-1 launch vehicle with a planned water landing

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and will serve as a final qualification flight for manned earth-orbital flight.

This flight will provide sufficient time at zero "g" (believed to be in excess of 20 minutes) for the operation of all systems. The flight will also provide for at least two starts of the Service Module Propulsion System with, as yet, an unspecified interval of time under zero "g" conditions before the second start. Crew safety will not be dependent on operation of the Service Module Propulsion System; however, the system may be used to provide additional time under zero "g" conditions' if required.

The planned tests on Project APOLLO AFRM-005 plus the successful demonstration of reentries by Project GEMINI flights will qualify the Project APOLLO heat shield for earth orbital reentry and will preclude flight qualification of the APOLLO heat shield prior to manned flight. Justification for the use of the Project GEMINI flights as qualification for APOLLO was based on the assumption that the APOLLO heat shield would be monolithic and of similar construction to the Project GEMINI heat shield.

Qualification flights of the Saturn C-1 Emergency Detection System will have been completed prior to the first manned flight. All planning for the manned flight will be based on the assumption that the abort system is manual, not automatic, and in the event that present studies dictate the use of a closed loop abort system, plans will be changed accordingly.

Bell-jar environmental tests at North American Aviation, Inc., will be used to qualify the Environmental Control System for manned sub-orbital flight.

The high altitude abort, the final high "q" abort, and the final pad abort are required to qualify the Reaction Control and Stabilization and Control Systems for manned sub-orbital flight. The high altitude abort and the final high "q" abort tests will also qualify the earth landing system. Components of the Communications Systems requiring flight qualification are not defined at the present time. The Electrical Power System, including the fuel cell, does not require flight qualification prior to manned flight.

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LITTLE JOE II LAUNCH VEHICLE DEVELOPMENT

A qualification flight of the Little Joe II launch vehicle is tentatively scheduled for July 1, 1963, at White Sands Missile Range, prior to flights with the APOLLO spacecraft. The first spacecraft flight (high "q" abort) will be made in August 1963, as scheduled. The dummy payload and inert Launch Escape System for the qualification flight will simulate the external shape and weight of the APOLLO spacecraft. The payload will not be recovered.

The contract negotiations for a definitized contract with General Dynamics/Convair for four airframes and two launchers were completed in November 1962. A definitized contract with Aerojet-General Corp., for rocket motors and development of a canted nozzle is scheduled to be negotiated in January 1963.

Wind tunnel model tests using Langley Research Center facilities have been completed and the data have been transmitted to the Contractor.

All drawings for the first Little Joe II launch vehicle and launcher have been completed. Construction of the first vehicle is progressing on schedule and construction of the launcher has started.

Construction of the canted nozzles for static tests has also started.

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FACILITIES

Industrial facilities at Downey, California, include manufacturing areas, office space, integration and checkout equipment, radiographic facilities, plaster master storage space, impact test site, space systems development complex, and data reduction equipment. Construction began on the impact test facility in December 1962, and is scheduled for completion in February 1963. The plaster master, radiographic, and bonding and test facilities construction contracts have been awarded. A&E design criteria are in various stages of formulation for the other facilities.

A preliminary design criteria study for the propulsion development test facility at White Sands Missile Range has been completed and approved by North American Aviation, Inc., and NASA. Final A&E design criteria are being prepared.

Contracts documents for the launch complex at White Sands Missile Range for Little Joe II and the pad-abort operations are complete and have been approved by NASA. Award of the construction contract is scheduled for January 1963.

Approval has been given for facilities, machinery, and equipment requirements previously submitted by Minneapolis-Honeywell Regulator Co., and to the R&D portion submitted by AVCO. Approval has been given to a portion of those submitted by Collins Radio Company. Beech Aircraft Company requirements are being reviewed for approval and those for Pratt and Whitney have not been received by NASA.

The APOLLO earth recovery system developmental and qualification tests will be supported by a C-133A aircraft. Douglas Aircraft Company is conducting engineering and also fabricating parts for the C-133A modification which will begin in early January 1963.

Interim environmental tests of the Command and Service Module are planned to be conducted at North American Aviation, Inc., to support the first manned flight. The MSC-Clear Lake facilities will be used to conduct later environmental tests instead of the Arnold Engineering Development Center Mark I altitude chamber.

Proposals for the design, development, and implementation of the IMCC were received at the MSC in early December 1962, and are presently being reviewed. It is expected that the contract award will be announced in late January 1963.

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PROGRAM ANALYSIS AND REVIEW TECHNIQUE

North American Aviation, Inc., is developing PERT for the Command and Service Modules and associated subsystems. They are constructing 24 networks to cover the major areas of functional responsibility. The 24 networks include the following:

- (a) Development, manufacturing and delivery of Command and Service Modules
- (b) Development, manufacturing and delivery of each subsystem
- (c) Design and construction of facilities
- (d) Checkout and test operations at Downey, White Sands Missile Range, and Atlantic Missile Range
- (e) Supporting operations such as flight technology, trainers, and AGE.

To date 21 of the 24 networks have been submitted to the MSC for review. Detail comments have been given to North American Aviation, Inc., on all of the networks that have been submitted, however, none of the networks have been approved. Four of the networks have been accepted on a trial reporting basis. General Dynamics/Convair has developed four networks to cover the design, manufacture and delivery of the Little Joe II launch vehicle. The four networks have all been approved and GD/Convair is reporting on these networks on a bi-weekly basis.

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1. "Project Apollo Lunar Landing Mission Design Plan," MSC, Apollo Spacecraft Project Office, Systems Integration. Confidential
2. W. N. Hess: The Artificial Radiation Belt. NASA Goddard Space Flight Center.

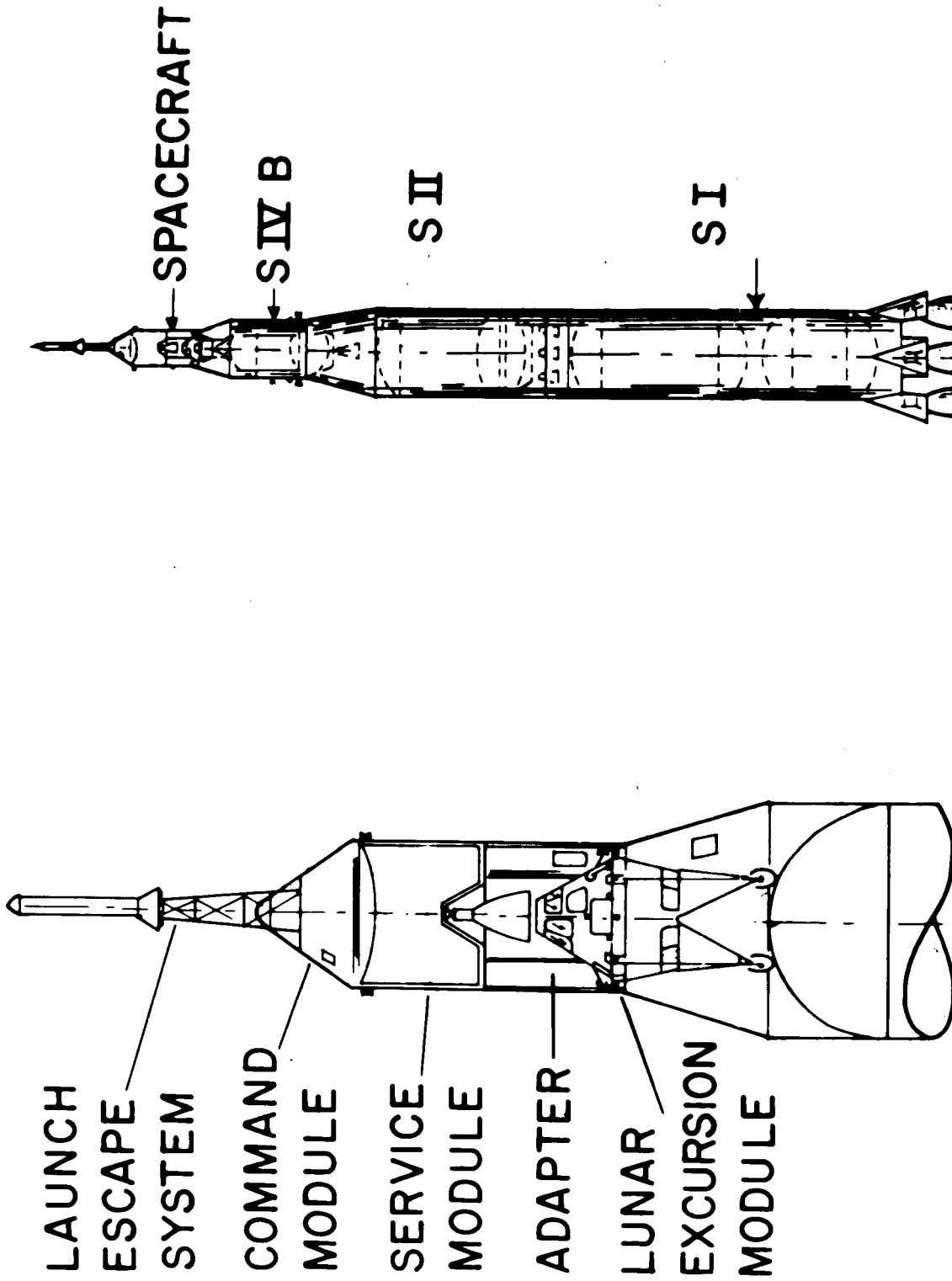


Figure 1. Apollo Space Vehicle Configuration

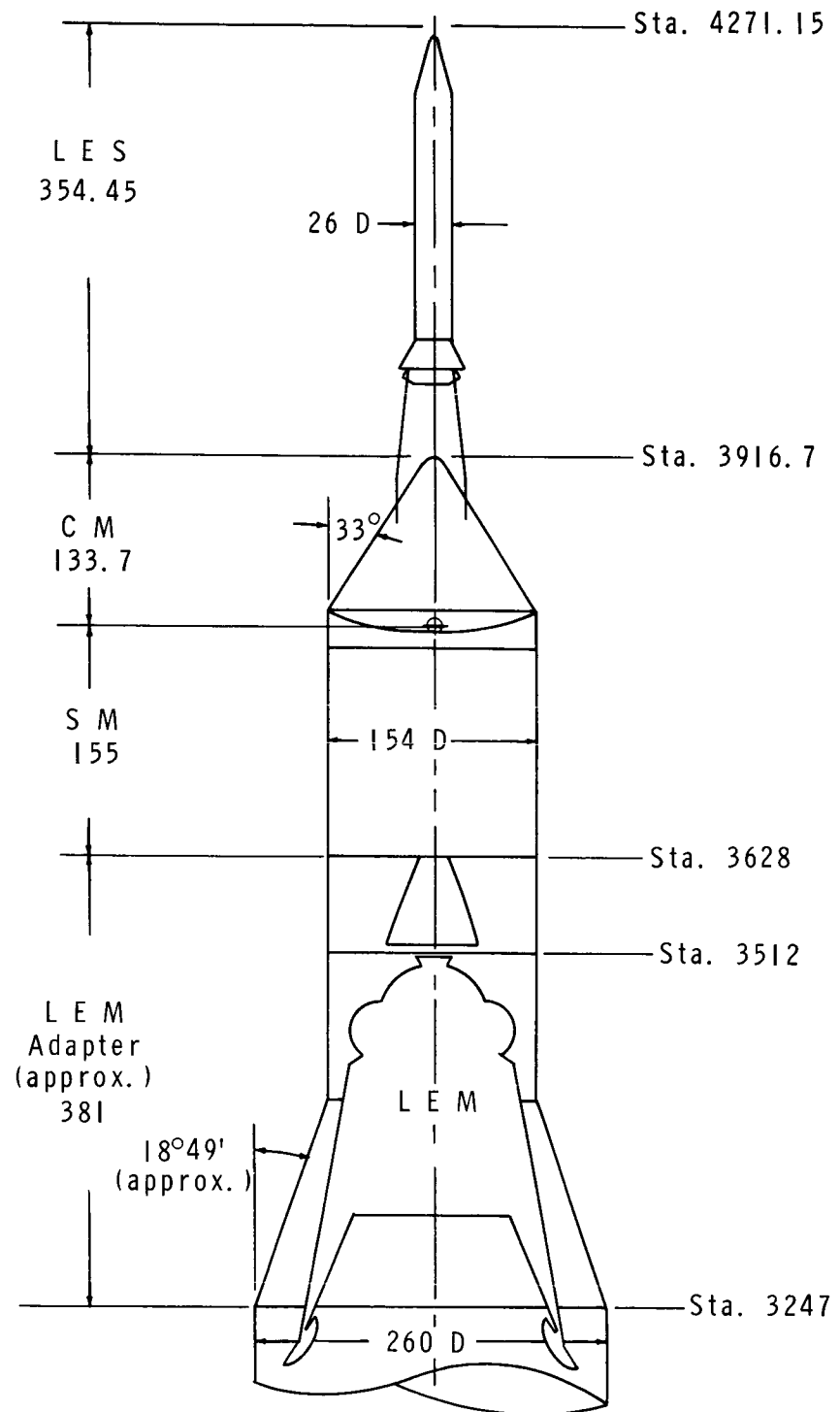


Figure 2. Apollo Spacecraft Configuration

